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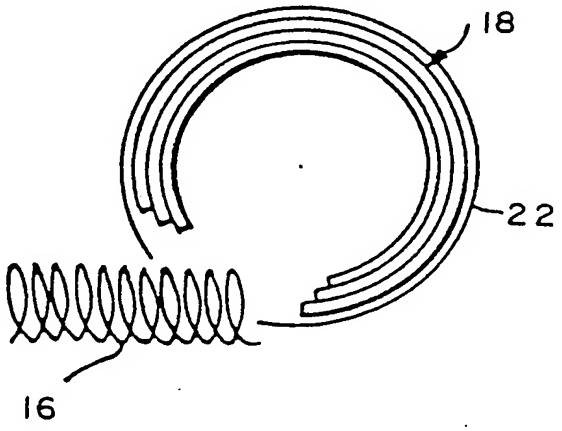
(54) Title: METHOD OF MANUFACTURING TOROIDAL COILS



(57) Abstract

Wire (10) is wound around a mandrel (14) until a desired number of turns have been wound. The mandrel (14) is then removed, and the resultant coil (16) is slipped over the end of a C-shaped core (18) having a relatively large gap (20). The core (18) is then bent to reduce the size of the gap (20). Preferably, the core is made in layers (24, 26, and 28) to facilitate bending of the core.

METHOD OF MANUFACTURING TOROIDAL COILS

Background of the Invention

The present invention is directed to the manufacture of coils such as those in inductors and transformers. It relates particularly to the manufacture of toroidal coils having ferromagnetic cores.

Complicated methods and apparatus have been proposed in the past for winding coils around C-shaped cores. The complexity arises principally from the fact that the wire is typically drawn from a spool, and it is difficult to avoid having to pass the spool through the "doughnut hole" of the core. Therefore, relatively elaborate mechanisms must be provided to pass the spool through the hole, and the spool used must be small enough to fit through the hole. A spool that small sometimes does not hold enough wire to wind the entire coil, so the spool must be replaced and the wire spliced during the operation.

The object of the present invention is to simplify the manufacture of toroidal coils having ferromagnetic cores.

Summary of the Invention

The foregoing and related objects are achieved in a method that includes winding the coil wire around a mandrel and then removing the mandrel to leave a coil that can be bent into a generally toroidal shape. A C-shaped ferromagnetic core is provided with a gap large enough to permit the wire at the end of the coil to fit into the gap so that the end of the core can be inserted into the end of the coil. The coil is then slipped over the core in a manner similar to that in which a sock is slipped over a foot. The core is preferably deformable

that it sticks to both the inside and the outside. Additionally, more than one strip of tape may be used if desired.

With the mandrel 14 removed, the wire 10 forms a coil 16, as FIG. 2 shows, that is ready to be placed on a C-shaped ferromagnetic core 18. The core 18, for reasons that will become clear presently, should be deformable. The gap 20 in the core is relatively large so that the wire at the end of the coil 16 can fit into the gap 20 and the end of the core 18 can be fit into the open end of the coil 16. The coil 16 is then slipped onto the core 18 in a manner similar to that in which a sock is slipped onto a foot, and a toroidal core like that shown in FIG. 3 results. It may be advantageous to provide a strap 22 around the outside of the core 18 before the coil is slipped on, as FIG. 2 shows, so that the ends of the strap can be pulled together and twisted to bend the core and thereby reduce the gap. The twisted strap can also serve to hold the core in its reduced-gap shape if the core is made of resilient material.

Although the last step in the process has been described as "bending" the core into the desire shape, the final shape of the core can be its rest shape, and the shape shown in FIG. 2 can be the result of applying force to the core to keep it spread while the coil is being slipped onto it. The "bending" would then be the relaxation of the core.

To facilitate the bending of the core, it can be provided as a group of thin concentric arcuate layers that are separate so that they can slide longitudinally with respect to each other. FIGS. 4 and 5 show the ends of such a core in detail as they look before and after bending to reduce the size of the gap 20. The core is shown for the sake of simplicity as being formed of only

1. A method of manufacturing a toroidal coil with a ferromagnetic core comprising the steps of:

A. winding a length of wire around a mandrel to make a coil of wire with first and second open ends through which the mandrel extends;

B. removing the mandrel from the coil to leave a central void extending between the open ends so that the coil can be flexed to form the coil in the shape of a C;

C. providing a C-shaped ferromagnetic core with a gap between its ends;

D. inserting one end of the C-shaped ferromagnetic core into one open end of the coil and slipping the coil over the core so that the coil is wrapped around the C-shaped core.

2. A method as defined in claim 2 further including the step of bending the core, after the coil has been slipped onto it, to reduce size of the gap.

3. A method as defined in claim 3 wherein:

A. the method further includes the step of providing a strap extending longitudinally along the periphery of the core;

B. the step of slipping the coil over the core includes simultaneously slipping it over the strap so that the ends of the strap extend out of the open ends of the coil; and

C. the step of bending the core includes drawing on the ends of the strap to bend the core and reduce the core gap.

AMENDED CLAIMS

[received by the International Bureau on 01 May 1987 (01.05.87);
original claim 1 amended; other claims unchanged (1 page)]

1. (Amended) A method of manufacturing a toroidal coil with a ferromagnetic core comprising the steps of:

A. winding a length of wire around a mandrel to make a coil of wire with first and second open ends through which the mandrel extends;

B. removing the mandrel from the coil to leave a central void extending between the open ends so that the coil can be flexed to form the coil in the shape of a C;

C. providing a C-shaped ferromagnetic core with a gap between its ends;

D. inserting one end of the C-shaped ferromagnetic core into one open end of the coil and slipping the coil over the core so that the coil is wrapped around the C-shaped core and assumes a generally toroidal shape.

2. A method as defined in claim 2 further including the step of bending the core, after the coil has been slipped onto it, to reduce size of the gap.

3. A method as defined in claim 3 wherein:

A. the method further includes the step of providing a strap extending longitudinally along the periphery of the core;

B. the step of slipping the coil over the core includes simultaneously slipping it over the strap so that the ends of the strap extend out of the open ends of the coil; and

C. the step of bending the core includes drawing on the ends of the strap to bend the core and reduce the core gap.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US87/00103

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

I.P.C.[4] H01F 41/06

U.S. Class. 29/605

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	29/605, 606; 336/217

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category [6]	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 1,994,534 (ROBINSON) 19 March 1935. (See column 2, line 53 through column 3, line 2).	1-4
Y	US, A, 2,586,320 (FORD) 19 February 1952. (See columns 3 and 4).	1-4
A	US, A, 1,592,352 (FRIEDRICH) 13 July 1926.	1-4
A	US, A, 1,594,292 (ZIERICK) 27 July 1926.	1-4
A	US, A, 1,656,933 (AHLSTRAND) 24 January 1928.	1-4

[6] Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [9]	Date of Mailing of this International Search Report [9]
30 March 1987	06 APR 1987
International Searching Authority [8]	Signature of Authorized Officer [10]
ISA/US	Carl Hall